



MADE EASY

Leading Institute for IES, GATE & PSUs

Delhi | Bhopal | Hyderabad | Jaipur | Pune

Web: www.madeeasy.in | E-mail: info@madeeasy.in | Ph: 011-45124612

CASTING+WELDING+FORMING

MECHANICAL ENGINEERING

Date of Test : 15/10/2026

ANSWER KEY ➤

- | | | | | |
|--------|---------|---------|---------|---------|
| 1. (d) | 7. (b) | 13. (b) | 19. (b) | 25. (a) |
| 2. (b) | 8. (a) | 14. (b) | 20. (c) | 26. (b) |
| 3. (a) | 9. (c) | 15. (c) | 21. (a) | 27. (a) |
| 4. (a) | 10. (d) | 16. (d) | 22. (a) | 28. (c) |
| 5. (a) | 11. (b) | 17. (b) | 23. (a) | 29. (a) |
| 6. (a) | 12. (b) | 18. (c) | 24. (b) | 30. (b) |

DETAILED EXPLANATIONS

1. (d)

2. (b)

$$\text{diameter, } d = 1000 \text{ mm}$$

$$\text{thickness, } h = 30 \text{ mm}$$

$$K = 2.1 \text{ sec/mm}^2$$

$$\text{Solidification time (T)} = K \left(\frac{V}{S} \right)^2$$

$$\begin{aligned} \text{Volume} &= \frac{\pi}{4} \times (1000)^2 \times 30 \\ &= 23561944.9 \text{ mm}^3 \end{aligned}$$

$$\begin{aligned} \text{Surface area} &= \left(2 \times \frac{\pi}{4} d^2 + \pi d h \right) = \frac{\pi}{2} \times 1000^2 + \pi \times 1000 \times 30 \\ &= 1665044.106 \text{ mm}^2 \end{aligned}$$

$$\begin{aligned} T &= 2.1 \times \left(\frac{23561944.9}{1665044.106} \right)^2 \\ &= 420.5 \text{ sec} \end{aligned}$$

3. (a)

$$\text{Diameter} = 400 \text{ mm}$$

$$\Delta h = 2R(1 - \cos \alpha)$$

$$1.25 = 2 \times 200(1 - \cos \alpha)$$

$$\left(\frac{1.25}{2 \times 200} \right) = (1 - \cos \alpha)$$

$$\alpha = 4.53^\circ$$

4. (a)

$$\eta_{\text{melting}} = \frac{\text{Net heat required to melt the joint}}{\text{Net heat supply}}$$

$$I = \frac{10 \times 5 \times 5 \times 10}{0.85 \times 0.60 \times 25} = 196.07 \text{ A}$$

5. (a)

Since there is no change in metal volume at a given point per unit time throughout the process, therefore

$$b_i h_i v_i = b_f h_f v_f$$

$$\frac{h_f}{h_i} = \frac{1}{3}$$

$$\frac{b_f}{b_i} = 1.03$$

$$v_f = \frac{b_i}{b_f} \frac{h_i}{h_f} v_i = \frac{1}{1.03} \times 3 \times 12 = 34.9514 \text{ m/min}$$

6. (a)

Solid phase welding is autogeneous welding processes.

Arc, gas, resistance and thermite welding processes are homogeneous welding processes as filler and parent material are same soldering and brazing processes are heterogenous as filler material is different from parent material.

7. (b)

Given: Weld per minute = 600, Diameter of electrode = 22 cm, Weld required = 4 per cm

Now, welding speed required

$$= \frac{\text{weld per minute}}{\text{weld required per cm}} = \frac{600 \text{ weld/min}}{4 \text{ weld/cm}}$$

$$= 150 \text{ cm/min}$$

$$\text{RPM of electrode} = \frac{\text{welding speed required}}{\pi \times \text{electrode diameter}} = \frac{150}{\pi \times 22} = \text{rpm}$$

$$= 2.17 \text{ rpm}$$

8. (a)

Given: Initial thickness, $t_1 = 20 \text{ mm}$

Final thickness, $t_2 = 16 \text{ mm}$

Radius of rolls, $R = 200 \text{ mm}$

$$t_1 - t_2 = 2R(1 - \cos \alpha)$$

$$20 - 16 = 2 \times 20 (1 - \cos \alpha)$$

$$\alpha = 25.84$$

$$\alpha = 25.84 \times \frac{\pi}{180} \text{ radians} = 0.451 \text{ radians}$$

9. (c)

Shrinkage allowance is always added to a linear dimension.

$$\text{Final inner diameter} = 10 + \frac{10 \times 0.2}{10} = 10.2 \text{ cm}$$

$$\text{Final outer diameter} = 20 + \frac{20 \times 0.2}{10} = 20.4 \text{ cm}$$

10. (d)

$$\text{Extrusion ratio} = \frac{A_0}{A_f} = \frac{\frac{\pi}{4} D_0^2}{\frac{\pi}{4} D_f^2} = \left(\frac{100}{50} \right)^2 = 4$$

11. (b)

$$\begin{aligned} \text{Shrinkage volume of casting} &= 0.026 \times 100 \times 100 \times 50 \\ &= 13000 \text{ mm}^3 \end{aligned}$$

$$\text{Volume of riser} = 4 \times 13000 = 52000 \text{ mm}^3$$

$$d^2 = \frac{52000 \times 4}{\pi \times 80}$$

$$d = 28.7681 \text{ mm}$$

12. (b)

$$\begin{aligned} \text{Energy utilized as heat} &= 0.8 \times VI \\ &= 0.8 \times 20 \times 200 \\ &= 3200 \text{ W} \end{aligned}$$

$$\therefore \text{Heat required} = V \times 10;$$

$$\therefore \text{Net heat available} = \text{Heat required}$$

$$3200 \times 0.625 = V \times 10$$

$$3200 \times 0.625 = v \times 8 \times 5 \times 10$$

$$\Rightarrow v = 5 \text{ mm/s}$$

$V \rightarrow$ Volume of nugget

(v : welding speed)

13. (b)

$$V_g = \sqrt{2 \times 10 \times 1000 \times 50} = 1000 \text{ mm/s}$$

$$\text{For top gate, } t_f = \frac{\text{Volume of mould}}{(\text{Area of gate}) (V_g)}$$

$$= \frac{150 \times 100 \times 50}{150 \times 1000} = 5 \text{ seconds}$$

$$\text{For bottom gate, } t_{f1} = 2 t_f = 10 \text{ seconds} \quad (\because h_m = h_s)$$

14. (b)

$$\begin{aligned} \text{Drawing force, } F &= \sigma_d \times A_f = 357 \times \frac{\pi}{4} \times (0.8 \times 10)^2 \\ &= 17944.777 \text{ N} \end{aligned}$$

$$\begin{aligned} \text{Power (P)} &= F \times V = 17944.777 \times 0.5 \\ &= 8972.38 \text{ W} = 8.97 \text{ kW} \end{aligned}$$

15. (c)

$$t = K \left(\frac{V}{SA} \right)^2$$

$$\text{For cube } \frac{V}{SA} = \left(\frac{a^3}{6a} \right)^2 \quad [\text{a is the side of cube}]$$

$$\frac{t_1}{t_2} = \frac{a_1^2}{a_2^2}$$

$$\Rightarrow t_2 = 5 \left(\frac{a_2}{a_1} \right)^2$$

$$V_2 = \frac{V_1}{8} \quad [\text{as density is constant}]$$

$$\Rightarrow a_2 = \frac{a_1}{2}$$

$$t_2 = \frac{5}{4}$$

$$t_2 = 1.25 \text{ minutes}$$

16. (d)

$$L(t) = L_0(1 + 2t^3)$$

$$\text{So, } dL = L_0(6t^2) dt$$

True strain (ϵ_T) at any instant of time,

$$\epsilon_T = \int_0^t \frac{dL}{L} = \int_0^t \frac{L_0(6t^2) dt}{L_0(1 + 2t^3)}$$

$$\Rightarrow \epsilon_T = \ln(1 + 2t^3)$$

and true strain rate at the end of 1 minute,

$$\left. \frac{d\epsilon_T}{dt} \right|_{t=1} = \frac{d(\ln(1 + 2t^3))}{dt} = \left(\frac{1}{1 + 2t^3} \right) (6t^2) \Big|_{t=1}$$

$$\dot{\epsilon}_T = \left\{ \frac{1}{1 + 2(1)^3} \right\} (6(1)^2) = 2.0 \text{ per min}$$

17. (b)

$$\text{Drawing stress, } \sigma_d = \sigma_o \left(\frac{1+B}{B} \right) \left[1 - \left(\frac{r_f}{r_o} \right)^{2B} \right]$$

For maximum reduction,

$$\sigma_d = \sigma_o$$

$$\Rightarrow 1 = \left(\frac{1+B}{B} \right) \left(1 - \left(\frac{r_f}{r_o} \right)^{2B} \right)$$

$$B = \mu \cot \alpha = 0.15 \cot \left(\frac{20}{2} \right) = 0.85$$

$$\text{So, } 1 = \left(\frac{1+0.85}{0.85} \right) \left(1 - \left(\frac{r_f}{r_o} \right)^{1.70} \right)$$

$$\Rightarrow \frac{r_f}{r_o} = 0.6963$$

Now, maximum possible reduction in area,

$$\frac{A_o - A_f}{A_o} = \frac{1 - (0.6963)^2}{1} = 51.50\%$$

18. (c)

For slush casting,

$$t = C_1 \sqrt{t_s} + C_2$$

$$t \propto \sqrt{t_s}$$

$$\Rightarrow \frac{t_1}{t_2} = \left(\frac{t_{s1}}{t_{s2}} \right)^{1/2}$$

$$\Rightarrow \frac{8}{2} = \left(\frac{25}{t_{s2}} \right)^{1/2}$$

$$\Rightarrow t_{s2} = 1.5625 \text{ min}$$

$$t_{s2} = 93.75 \text{ seconds} \simeq 94 \text{ seconds}$$

19. (b)

Given: $h_i = 20 \text{ mm}$, $h_f = 18 \text{ mm}$, $\Delta h = h_i - h_f = 2 \text{ mm}$

Maximum draft possible $(\Delta h)_{\max} = \mu^2 R$
 $= (0.15)^2 (200) = 4.5 \text{ mm}$

$$\text{Roll strip length, } l_p = \sqrt{R(\Delta h)} = \sqrt{(200)(2)} = 20 \text{ mm}$$

$$\text{Rolling force, } F = l_p \times w \times \bar{\sigma}_f$$

$$F = 20 \times 250 \times 165.8 = 829 \text{ kN}$$

Now, Torque required to drive each roll,

$$\begin{aligned} T &= a \times F = 0.5 l_p \times F \\ &= 0.5 \times 20 \times 829 = 8290 \text{ kN-mm} \\ T &= 8290 \text{ Nm} \end{aligned}$$

20. (c)

From volume consistency,

$$\pi(30)^2 \times 30 = \pi r_f^2 \times 15$$

$$\therefore r_f = 42.42 \text{ mm}$$

True strain at the end of the stroke

$$\epsilon = \ln \left(\frac{30}{15} \right) = 0.69$$

$$\sigma_f = 800 \times (0.69)^{0.2} = 742.78 \text{ MPa}$$

Force at the end of the stroke,

$$\begin{aligned} F &= \sigma_f \pi r_f^2 \left(1 + \frac{2\mu r_f}{3h_f} \right) \\ &= 742.78 \times \pi \times (42.42)^2 \left(1 + \frac{2 \times 0.2 \times 42.42}{3 \times 15} \right) \times 10^{-6} \\ &= 5.78 \text{ MN} \end{aligned}$$

21. (a)

$$\text{Contact strip length, } L = \sqrt{R\Delta h} = \sqrt{500 \times (1 - 0.8) \times 25} = 50 \text{ mm}$$

$$\text{True strain, } \epsilon = \ln\left(\frac{25}{20}\right) = 0.223$$

$$\text{Average flow stress, } \sigma_f = \frac{250 \times (0.223)^{0.2}}{1.2} = 154.32 \text{ MPa} \quad \left[\sigma_f = \frac{k\epsilon^n}{n+1} \right]$$

$$\begin{aligned} \text{Rolling torque, } T &= Fa = \sigma_f bL \times \frac{L}{2} = 154.32 \times 250 \times 50 \times \frac{50}{2000} \times 10^{-3} \\ &= 48.225 \text{ kN-m} \end{aligned}$$

$$\begin{aligned} \text{Power} &= 2T \times \frac{V}{r} = 2 \times 48.225 \times \frac{0.5}{0.5} \\ &= 96.45 \text{ kW} \end{aligned}$$

22. (a)

$$\text{Heat for melting, } H_m = UV$$

$$V = \frac{\pi}{4} d^2 t = \frac{\pi}{4} (5)^2 \times 2.5 = 49.087 \text{ mm}^3$$

$$\text{Heat supplied, } H_s = 4H_m = 4 \times 9 \times 49.087 = 1767.132 \text{ J}$$

$$H_s = \int_0^t I^2 R dt = (10^5)^2 \times 100 \times 10^{-6} \int_0^t t^2 dt = \frac{10^6 t^3}{3}$$

$$t = \left(\frac{3 \times 1767.132}{10^6} \right)^{1/3} = 0.174 \text{ seconds}$$

23. (a)

$$\text{Time taken for filling mold, } t_f = \frac{V}{A_g v_g}$$

$$A_g v_g = \text{Volumetric flow rate} = 25 \text{ cm}^3/\text{min}$$

$$V = \text{Volume} = \frac{40 \times 10 \times 10}{1000} = 4 \text{ cm}^3$$

$$t_f = \frac{4}{25} \text{ min} = 0.16 \text{ min}$$

24. (b)

Here, $\epsilon_y = \ln\left(\frac{75}{80}\right) = -0.0645$

$$\sigma = 400(0.0645)^{0.2} = 231.21 \text{ MPa}$$

Now, $\frac{\sigma}{\epsilon_{el}} = E$ (where, ϵ_{el} : Elastic strain)

$$\Rightarrow \epsilon_{el} = \frac{231.21}{100 \times 10^3} = 2.3121 \times 10^{-3}$$

$$\begin{aligned} \text{Length recovered} &= L \times \epsilon_{el} \\ &= 80 \times 2.3121 \times 10^{-3} = 0.185 \end{aligned}$$

$$\text{Final dimension } (L') = 75 + 0.185 = 75.185 \text{ mm}$$

25. (a)

$$t = k \left(1.41 + \frac{T}{14.59} \right) \sqrt{w} \text{ sec}$$

$$T = 1.1525 \text{ cm} = 11.525 \text{ mm}$$

$$t = \frac{28}{40} \left[1.41 + \frac{11.525}{14.59} \right] \times \sqrt{20} \text{ sec} = 6.8868 \text{ sec}$$

$$= \frac{6.8868}{60} \text{ minutes} = 0.11478 \text{ minutes}$$

26. (b)

$$\text{Mean flow stress } (\bar{\sigma}_0) = \frac{k \epsilon^n}{1+n}$$

$$k = 600 \text{ MPa}$$

$$n = 0.15$$

$$200 = \frac{600 \times \epsilon^{0.15}}{1+0.15}$$

$$\epsilon = 1.67 \times 10^{-3}$$

$$\sigma = 600 (1.67 \times 10^{-3})^{0.15}$$

$$\text{True stress, } \sigma = 230 \text{ MPa}$$

27. (a)

$$\text{Length of contact, } L_p = R \sin \alpha = \sqrt{R \Delta h}$$

$$\Delta h = 2R(1 - \cos \alpha)$$

$$5 = 2 \times 150 (1 - \cos \alpha)$$

$$\frac{5}{300} = 1 - \cos \alpha$$

$$\Rightarrow \alpha = 10.4753^\circ$$

$$L_p = 150 \times \sin 10.4753^\circ = 27.27 \text{ mm}$$

$$\text{Roll separating force, } F = \sigma_0 L_p \times b = 195 \times 27.27 \times 100 = 0.531 \text{ MN}$$

Ans. 27.5 mm, 0.531 MN

28. (c)

Given: $L = 1000 \text{ mm}$, $d = 750 \text{ mm}$, $k = 2 \text{ s/mm}^2$,

$$\text{Solidification time (t)} = k \left(\frac{V}{A} \right)^2$$

$$\begin{aligned} \left(\frac{V}{A} \right)_{\text{cylinder}} &= \frac{\frac{\pi}{4} D^2 L}{2 \times \frac{\pi}{4} D^2 + \pi D L} = \frac{D^2 L}{2D^2 + 4DL} \\ &= \frac{(750)^2 \times 1000}{2(750)^2 + 4 \times 750 \times 1000} = 37190.08 \text{ s} = 619.83 \text{ minutes} \end{aligned}$$

29. (a)

Given:

$$d = 0.13 \text{ m} \qquad h = 0.2 \text{ m}$$

$$\rho_c = 1500 \text{ kg/m}^3, \qquad \rho_z = 12000 \text{ kg/m}^3$$

$$\begin{aligned} \text{Net force} &= g \cdot V (\rho_z - \rho_c) = 9.81 \times \frac{\pi}{4} \times (0.13)^2 \times 0.2 (10500) \\ &= 273.442 \text{ N} \end{aligned}$$

30. (b)

$$\epsilon = \ln \left(\frac{A_i}{A_f} \right) = 2 \ln \left(\frac{d_i}{d_f} \right) = 2 \ln \left(\frac{30}{6} \right) = 2 \ln 5 = 3.22$$

$$\text{Average flow stress, } \bar{\sigma} = \frac{\sigma_o \times \epsilon^n}{1+n} = \frac{315 \times 3.22^{0.44}}{1+0.44} = 365.93 \text{ MPa}$$

